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ALFRED R. C. SELWYN, F.R.S., F.G.S., DIRECTOR.

REPORT

ON THE

SUPERFCIAL GEOLOGY

OF SOUTHERN

NEW BRUNSWICK

1878

BY

G. F. MATHEW, M.A., F.G.S.



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1879

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ALFRED R. C. SELWYN, F.R.S., F.G.S.,

Director of the Geological Survey of Canada.

SIR,—The following description of the superficial deposits in the southern part of New Brunswick includes the results of observations, made at intervals, during the last ten years or more. These observations have been made chiefly in connection with the survey of the older rocks of the Province named, and have, in part, been published in the *Canadian Naturalist*, Montreal.* The substance of the articles in that periodical has been combined, in this Report, with later observations, into a connected description of the Superficial Deposits.

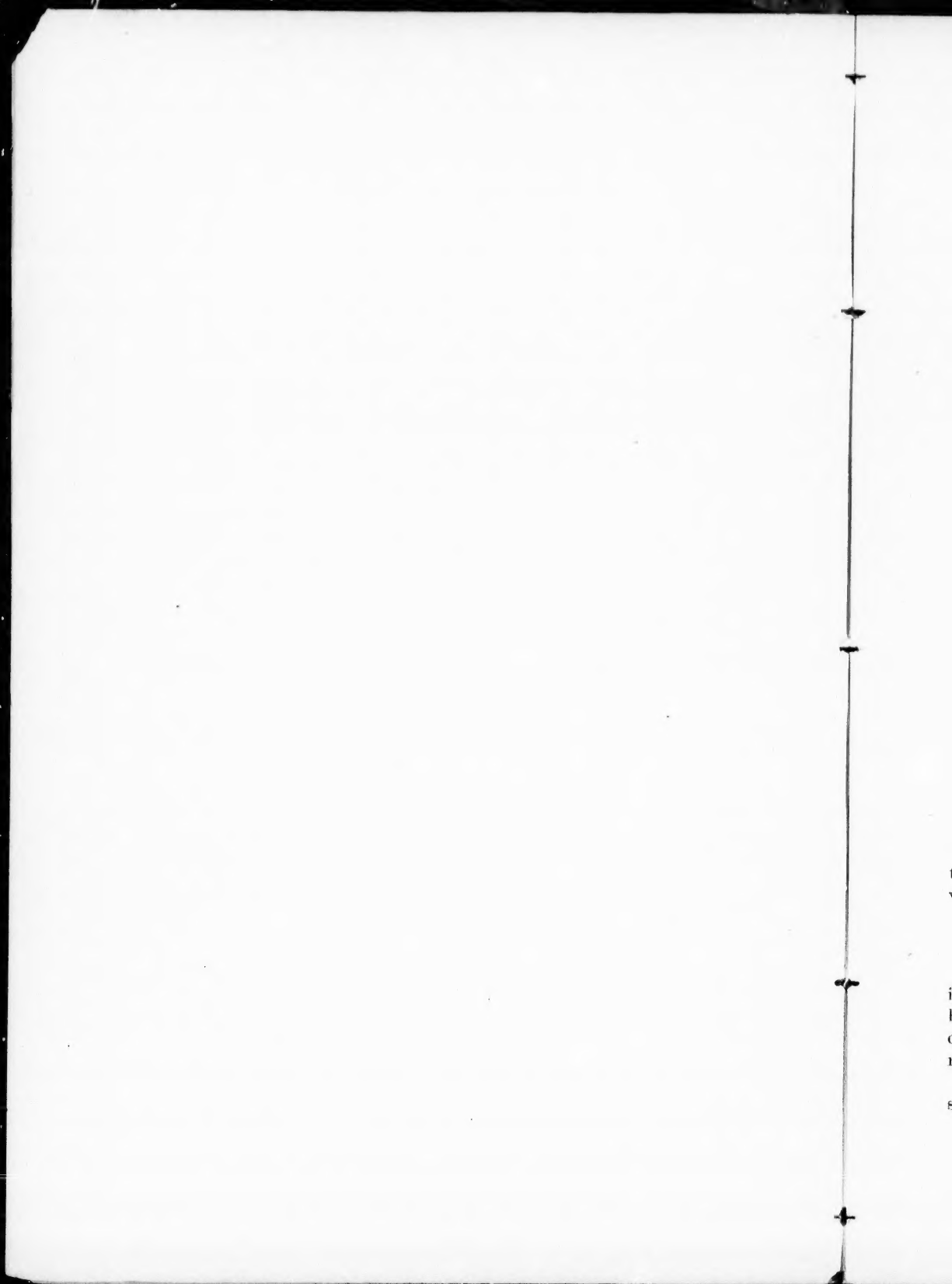
I am, sir,

Your obedient servant,

G. F. MATHEW.

St. John, N.B., December, 1878.

* See *Canadian Naturalist*, New Series, Vol. 6, No. 1; Vol. 7, No. 8, and Vol. 8, No. 2.



REPORT
ON THE
SUPERFICIAL GEOLOGY
OF
SOUTHERN NEW BRUNSWICK,
BY
G. F. MATHEW, F.G.S.

The superficial deposits may be considered as forming three principal groups, viz. :— Classification.

- I. Unmodified or Glacial Drifts, Boulder Clay, or Till.
 - II. Modified Drift.
 1. Stratified Sand and Gravel (Syrtesian Deposits).
 2. Leda Clay (Estuarine Deposits).
 3. Saxicava Sand and Raised Beaches (Littoral Deposits).
 - a. Lower Leda Clay.
 - b. Upper Leda Clay.
 - III. Modern Alluvium, Shell, Marl, Peat, &c.
-

These deposits consist of an aggregation of loose materials covering the older rocks, which have been consolidated, and afterwards extensively denuded before the formation of the oldest of the above groups.

I.—UNMODIFIED DRIFT, BOULDER CLAY OR TILL.

This group is not only the most widely distributed of the three, but is found at all elevations, and is that from which the materials have been derived of which the later ones are composed. A description of the boulder clay and the related phenomena of striated and grooved rocks will therefore naturally form the opening part of this Report.

Great masses of the unmodified drift underlie the brick-clays of the second group in many parts of the State of Maine and the Provinces of

Composition of
Boulder Clay.

Quebec and New Brunswick, and spread upward to the tops of the highest hills in southern New Brunswick, where, so far as is known, they present all the appearance of a true till, or boulder clay. The later groups evince to a greater or lesser degree by their appearance the sorting power of water, but the boulder clay alone is unstratified throughout. It consists of sand and clay promiscuously mingled, and contains numberless striated stones, and angular fragments of rocks having no definite arrangement in the mass. From the sea level to a height of at least 200 feet above it, the boulder clay has been greatly modified by the action of waves and currents, and within these limits is usually concealed by the clays, sands and gravels of the second group; but at higher levels the unmodified drift is more frequently exposed, with its characteristic features—intermingled sand, clay and striated boulders.

Transportation
of Boulders.

In general, the stones of the boulder clay are not moved very far from the places where they have been *in situ*. Ten miles or less is the usual limit, but instances occur in which the transportation has been for much longer distances. The following are the most remarkable instances of travelled boulders observed by Prof. L. W. Bailey and the writer:—At Bradford's Cove, on the St. Croix River, are stones containing large Spirifers and other fossils of Devonian age similar to those of the Oriskany Sandstone in the northern part of Maine. Fragments with similar fossils occur on Grand Manan Island, in the Bay of Fundy. A few miles north of St. Stephen a boulder of labradorite was observed, which Dr. T. S. Hunt recognized as the kind of rock which occurs in the Laurentian of the Province of Quebec. At St. John, I have seen trap with heulandite similar to a characteristic variety in the Lower Carboniferous formation at Grand Lake, in Queens county; also pieces of a felspathic sandstone, with Upper Silurian fossils, from Nerepis Valley, in the same county. In the till covering the granite hills in the Nerepis Valley there are comparatively few boulders from any great distance, the stones in the boulder clay being chiefly of slate, shale and sandstone, which have been swept across the plain of Carboniferous rocks and pushed up to the summits of these hills. Here they are mingled with numberless boulders of red and tawny granite derived from the surrounding ledges; but among the blocks of red granite there are a few well-rounded boulders of grey granite, that have come across the Carboniferous area of Sunbury county from the granite belt in the north part of York and Northumberland. Along the south side of this granite range there is a belt a few miles wide, covered with immense numbers of boulders; on the headwaters of the Lepreau and New rivers they are especially numerous. Granite boulders become less numerous in going south from the foot of

this range, and their place is gradually taken by the slate, gneiss and dioritic fragments of the ledges in the lowlands, but even on the shores of the Bay of Fundy great numbers are still to be seen. A good instance of upward transportation is that of the stones on the top of Bald Mountain, the highest hill of the Nerepis range. Among these stones are numerous fragments of coarse diorite and hypersthene, which have been swept up a steep slope on the north side of the hill from ledges 500 feet below the summit. Along the sides of transverse narrow valleys among these hills, and behind points of rocks, there are horizontal belts of boulders which have the appearance of having been forced or carried by ice into these positions.

The color of the boulder clay and overlying clay of the second group of superficial deposits is worthy of notice, as shewing the sources whence the clays have been derived. In the country west of the Magaguadavic Bay they are of various shades of grey, from ash-grey to a dark mouse-color, and such also are the prevailing tints in the adjoining part of the State of Maine. These grey tints are traceable to the wide bands of argillites that cross the northern part of Charlotte county and the southern part of York; the darker shades of grey originate in the Upper Silurian bands of clay-slates and the lighter greys in the Devonian argillites. The latter are generally calcareous, and the boulder clays from this source have a more ferrous than those derived from other rocks in Charlotte county. The color of the clays in the western part of this county is very different from that to the sea shore, where, owing to their hardness, the boulders of the Upper Silurian series seem to have caused the color of the clay.

Color of the
Boulder Clay.

The north-east branch of the Magaguadavic drains the northern margin of the Carboniferous area, and has cut its channel in the soft shales, of the Lower Carboniferous formation, which appear along its valley; here a change begins in the color of the clays, which shews itself chiefly in the contrast between the Leda clay and the underlying gravels in the valley of the Magaguadavic, as far down as the mouth of the Piskahegan. The Leda deposit here is mostly sand, but is distinguished from the older modified drift (*i.e.*, the underlying gravels) by its reddish tint. In the granite hills, further east, the red shade becomes more pronounced, varying from a pale fox-color to a warm reddish-brown tint; the clays obtain this deeper shade from the ochre-red Lower Carboniferous beds, and from the purplish-red and chocolate-brown shales of the coal measures in York and Sunbury counties. Still deeper shades of red and brown prevail in the clays of St. John county, to the northward of which areas of bright or deep red and chocolate-brown shales are more extensive than in York or Sunbury.

Red Color from
Carboniferous
Shales.

This peculiar coloring of the clays in the central part of southern New Brunswick shows that the eroding force was much more destructive in its effects upon the soft but low-lying and comparatively sheltered shales, than on the more prominent but harder rocks of the ridges and hills.

The fertility of the clay lands of this district may also be traced to the deposits of Lower Carboniferous shales to the north of them, which are sometimes highly calcareous, and have included beds of limestone.

Glacial Grooves.

Wherever the boulder clay is removed from the surface of the rocks upon which it rests, these are found to be rounded and scored with parallel grooves and furrows, caused by the action of ice in motion prior to the deposition of the boulder clay. The course of these grooves varies greatly in different regions; in the valley of the St. Lawrence it is south-westerly, and in the eastern part of Maine south-easterly. The striae on the rocks in the southern counties of New Brunswick exhibit both these trends. A south-easterly course is most prevalent in the western part of Charlotte county, and south-westerly striae are most numerous in the valleys east and north-east of St. John. These two general courses, as well as the intermediate ones, will be seen to be related to the contour of the surface of the land in the several districts where they occur; for, as a general rule, the furrows conform to the direction of the river valleys, or at least are influenced in their course by these depressions.

In the following table all the bearings are corrected to the true meridian. Such striae or grooves as have been observed by Prof. L. W. Bailey are marked with an asterisk; those taken by Mr. R. W. Ellis are indicated by an obelisk. Grooves described as "other striae" are generally older than those recorded in the margin:—

Two general
courses in
southern New
Brunswick.

No. 1 TABLE OF GLACIAL GROOVES.

No.	PARISH.	LOCALITY.	Exposure.	Course.
<i>S. W. part of York County.</i>				
1	Prince William	On E. & N. A. Railway, 3 miles S. W. from McAdam Junction	..	S. 45° E.
2	Manners Sutton.	S. end of ridge running N. W. from N. end of Oromocto Lake. Latest striae S. 60° E. and S. 40° E.	S. W.	S. 20° E.
3	"	Harvey Settlement,—road leading to Lester's mill. Latest striae S. 45° E. and S. 50° E.	E.	(S. 20° E. S. 10° E.)
4	"	Harvey Settlement, chapel in. Latest striae S. 45° E. (few)	..	S. 20° E.
5	"	Cork Settlement ridge, one mile north of Cork Station. Latest striae S. 20° E. (few)	E.	S. 30° E.
6	"	Cork Station	S. W.	S. 20° E.
<i>Charlotte County to and including Magalloway Valley.</i>				
* 7	St. Stephen.....	Dennis Stream, 1½ miles from	..	S. 50° E.
8	St. David's.....	Oak Bay, east side of, opposite S. end of Roger's Island	W.	S. 45° E.
* 9	"	On St. Stephen Branch R. R., Meadow Station	..	S. 40° E.
10	St. Croix.....	Bradford's Cove. Latest striae S. 10° E.	..	S. 40° E.
11	"	Shore of St. Croix River, opposite Doucet Island. Latest striae S. 20° E., in a valley	..	S. 5° E.
* 12	"	Chamcook Mountain, W. end of, under cliff overhanging about 60°	W.	S. 10° E.
13	"	Chamcook Lake, E. shore of, on E. side of a ledge that overhangs 20°. Striae converge from N. W. on the overhanging face	E.	S. 50° E.
14	"	Chamcook Lake, near outlet. Latest striae S. 25° E.	W.	S. 45° E.
15	St. Andrew's....	Chamcook Cove, E. side. Latest striae S. 10° E.	S. W.	S. 50° E.
16	Pembroke.....	Village, State of Maine, U. S.	N.	S. 40° E.
* 17	"	River, West Branch, State of Maine, U. S.	..	S. 50° E.
18	Eastport.....	State of Maine. Broad Cove—N. E. slope of a rounded ledge S. 60° E. On N. W. slope of same ledge	N.	S. 55° E.
* 19	West Isles.....	On Deer Island. Other striae S. 65° E.	..	S. 50° E.
* 20	"	Pendleton's Island, N. E. end of	S. W.	S. 65° E.
21	Dumbarton.....	Wichee Ridge, south slope of	S. W.	S. 60° E.
22	St. Patrick.....	Bocabee Bay, head of. Latest striae S. 10° E.; other striae S. 20° E.; oldest striae	..	S. 40° E.
23	"	Near by, on ledge protected by a higher ledge to the N. N. 70° E. Bocabee Bay. E. point of last striae S. 5° E.; other striae S. 20° E.	W. N. W.	S. 40° E.

No. 1 TABLE OF GLACIAL GROOVES.—Continued.

No.	PARISH.	LOCALITY.	Exposure.	Course.
24	"	Bocabee Lake. North side of last striae S. 35° E.	S. W.	S. 25° E.
* 25	"	Bocabee River. Other striae S. 55° E.	E.	S. 45° E.
* 26	"	Bocabee Bridge. Other striae S. 70° E.	N. W.	S. 30° E.
27	"	Duncan road, 1½ miles N. from Turner's mills.	N. E.	S. 25° E.
28	"	Digdeguash Valley, near N. end of Duncan road. Latest striae N. 70° E.	E.	S. 30° E.
29	"	Digdeguash Basin, W. of mill at, in deep, narrow valley; course S.	..	S. 30° E.
30	St. George	Hill between Piskahegan and Magaguadavic River, N. slope of	W.	S. 60° E.
* 31	"	Magaguadavic River, mouth of estuary, N. side, on steep ledge	S. S. W.	S. 80° E.
		Near by, on another ledge; other striae S. 55° E.	..	S. 60° E.
32	"	Creek, on south side of estuary of Magaguadavic River	N. W.	S. 85° E.
33	"	Letite, mill-cove Brook, at	N. W.	S. 60° E.
34	"	Letite Harbor, head of. Last striae S. 75° E.	N. W.	S. 25° E.
35	"	Magaguadavic River, falls of. Other striae S. 80° E.	S. W.	S. 60° E.
* 36	"	Lake Utopia, W. side of	..	S. 20° E.
37	"	L'Etang River, N. W. side of basin at head of. Later striae S. 80° E.	N. E.	S. 60° E.
38	"	L'Etang River, S. W. side of basin at head of. Later striae S. 80° E.	W. N. W.	S. 60° E.
39	Pennfield	L'Etang River, E. side of basin at head of.	S.	S. 15° E.
40	"	L'Etang River, ridge S. E. of	N. W.	S. 5° E.
41	"	L'Etang River, E. side of narrows of High hill on W.	N.	S. 60° E.
* 42	"	L'Etang Harbor, Bliss Island, at	N. E.	S. 30° E.
43	"	Black's Harbor	..	S. 60° E.
44	"	Beaver Harbor, Head of. Older striae S. 30° E.	N.	S. 60° E.
45	"	Beaver Harbor. On ridge S. of last. On S. E. slope of ridge is a rounded ledge 4 × 10 × 30 feet, exposed on road side. Oldest striae S. 10° W.; latest striae S. 80° E.; chief striae S. 30° E., curving to	(S. E.)	S. 40° E.
		On N. side of ledge are a few later striae S. 20° E.	..	..
46	"	Point between Deadman's and Beaver harbors.	..	S. 10° E.
<i>Charlotte County—Eastern part.</i>				
47	Clarendon	Bear Brook (broad valley)	N.	S.
48	"	Sand Brook (narrow valley)	N.	S. 10° E.
49	"	McLeod road, 1½ miles from Douglas Valley	N. W.	S. 10° E.
50	"	Falls Brook, in an open valley	N.	S. 20° E.
51	Lepreau	Harbor, north side	S.	S. 10° E.
* 52	Lepreau	Basin, eastern end	W.	S. 20° E.

No. 1 TABLE OF GLACIAL GROOVES.—Continued.

No.	PARISH.	LOCALITY.	Ex- posure.	Course.
<i>Sunbury and Queen's Counties.</i>				
53	Blissville	Fredericton Junction, E. & N. A. R. R., Ridge one mile S. of	N.N.W.	S. 5° E.
54	"	Forks of Fredericton and Clones road ..	N.N.E.	S. 25° E.
55	Petersville	Fredericton road, E. side of Stony Ridge	N. E.	S. 20° E.
		Parish Church, Headline Hill	..	S. 35° E.
56	"	Ollinville Settlement	..	S. 60° E.
† 57	"	Wilson road, in Clones Settlement.		
58	Gagetown	Oldest striae S. 35° E.; chief striae S. 45° E., curving to	(S.W.)	S. 40° E.
59	Hampstead	E. of Blue Mountain, on slope to Long Lake	N. E.	S. 35° E.
† 60	Northfield	Newcastle River, above Yeoman's Bridge	N.	S. 15° W.
<i>King's County.</i>				
* 61	Westfield	On E. & N. A. R. R., 8 miles from Fair- ville	..	S. 40° E.
62	"	Near bridge over mouth of Nerepis River, W. side of valley. Striae course S. 75° E., bending round end of ledge to Near top of hill overlooking this point.	..	S. 65° E.
* 63	"	Brittan's Point, hill S. W. of Parsonage	E.	E.!
64	"	Summit of Hill, 525 feet high, near Land's End	..	S. 20° E.
65	"	Kennebecasis Island, N. side of (S. of a ridge running N. E.)	..	S. 10° E.
66	"	Kennebecasis Island, N. E. end of hill to E.	S. W.	S. 30° W.
67	"	Carter's Point, near corner of road to Finer striae cut on points left by these grooves and mark the bottoms of these grooves. Course of the fine striae W.!	S.S.W.	S. 20° W.
68	"	Milkish Valley, on its S. E. slope. Course of valley S. W.	N.	S.
		These striae found only on faces sloping to N.; another fainter set run into the deeper hollows and grooves exposed to a down-hill thrust from the E. Course S. 60° W.!	N.W.	S. 15° E.
69	"	Milkish Valley, East of	S. W.	S. 20° E.
70	"	Milkish Valley, N. side of a low gneissic ridge. Other striae S. 20° E.	W.	S. 50° E.
71	Greenwich	Devil's Back, N. side of, on pp. sandst. .	N.	S. 25° W.
72	Kingston	On Long Reach road, near Whelphy's Beach	S. W.	S. 5° E.
		Also lighter scratches, showing only on S. E. slopes	..	
73	"	Centreville, eastern base of hill (500 feet high) to S. of	E.	S. 20° E.
74	"	Centreville, hill to E. of (Midland road)	W.	S. 5° E.
75	"	Bostwick's Brook, on Long Reach	N.	S. 5° E.
† 76	"	Bellisle Bay, S. side of	N.	S. 15° E.
77	Rotherham	Golden Grove Settlement, S. side of valley	N.	S. 5° E.
78	Upham	Barnesville, road going E. from, hill on	N.	S. 15° E.

No. 1 TABLE OF GLACIAL GROOVES.—*Continued.*

No.	PARISH.	LOCALITY.	Ex- posure.	Course.
* 79	"	Barnesville, same road, 2 miles E. of last, on ridge facing a deep valley running N	E.	S. 10° E.
* 80	"	Hill N. of McCoy's corner, on opposite (E.) side of last-named valley	"	S. 10° E.
* 81	Hammond	John Wallace's, 1 mile E. of Walton Lake	N.	S. 65° E.
82	Musquash	W. branch Musquash River, at Mill Valley, E.	N.N.W.	S. 50° E.
83	"	Village, at McGowan's Inn.	S. E.	S. 20° E.
84	"	Musquash Harbor, W. side of Narrows	E.	S. 40° E.
85	"	Musquash Harbor, Connor's Cove, E. side	N.W.	S. 30° E.
86	"	Musquash Harbor, Frenchman's Creek, at bridge, in narrow valley. Other striae S. 5° E.	N.	S. 20° E.
* 87	Lancaster	Spruce Lake, near outlet	N.W.	S. 40° E.
88	"	Pisarinco Cove, Mill Creek. Other striae S. 50° E.	N.W.	S. 40° E.
89	"	Pisarinco Cove, N. side	"	S. 35° E.
* 90	"	On E. & N. A. R.R., 4 miles from Fairville	"	S. 40° E.
* 91	"	South Bay Mills. Other striae S. 15° E.	N. E.	S. 40° E.
* 92	"	On E. & N. A. R.R., 3 miles from Fairville	N.N.E.	S. 30° E.
* 93	"	W. end of Suspension Bridge	N.N.E.	S. 21° W.
94	"	Sand Cove road. Striae on a steep ledge sloping N. W., deflected to S. 80° from	(N.W.)	S. 40° E.
95	Carleton	Queen Square, on ledge sloping N. Other striae S. 4° E.	N. E.	S. 2° W.
96	"	Belltower Hill, under steep ledge facing Same place, top of hill	N.	S. 15° W.
97	Simonds	Lawlor's Lake, summit of valley at. Other striae S. 20° W.; fainter striae S. 30° W. and S. 45° W.	"	S. 4° E.
98	"	On Black River road, 3 miles E. of St. John	N. E.	S. 35° W.
99	"	On Black River road, 1 mile N. E. of Mispec Bridge	W.	S. 2° W.
100	"	Mispec Harbor, in valley running S.S.W.	"	S. 35° W.
101	"	Mispec, Thomas's Cove, near road	S.	S. 15° W.
102	"	Black River road at Brandy Brook	N.	S. 40° W.
103	"	Beverage Cove road. Other striae S.	"	S. 20° W.
104	"	Beverage Cove road, descent to Bay of Fundy. Other striae S. 35° E.	"	S. 15° W.
105	"	Thompson's Cove road	S. E.	S. 50° E.
106	"	Thompson's Cove road, slope to Bay of Fundy	"	S. 30° E.
* 107	"	Negro Settlement, N. side of valley of Black River	"	S. 40° E.
* 108	"	Hibernia road, 3 miles S. of L. Lomond Mountain road to Black River Settlement, at Bloomsbury Mountain	"	S. 50° E.
109	"	Hibernia Settlement, $\frac{1}{2}$ mile N. of Dougherty's Inn	S. W.	S. 25° E.
* 110	"	Hibernia Settlement, $\frac{1}{2}$ mile S. of Dougherty's Inn	S.	S. 20° E.
* 111	"	S. 10° E., S. 25° E., and	W.	S. 20° E.
112	"	Lake Lomond, N. side of First Lake, at thoroughfare to Second Lake	S. E.	S. 20° E.

No. 1 TABLE OF GLACIAL GROOVES.—*Continued.*

No.	PARISH.	LOCALITY.	Exposure.	Course.
113	"	Lake Lomond, N. side of Third Lake, near Lake level	S.	S. 20° E.
*114	St. Martin's.....	Hill W. of Henry's Lake	E.	S.
<i>Albert and Westmoreland Counties.</i>				
†115	Elgin(Albert Co)	On road from Elgin to New Ireland, on mountain S. of Caldicott's Inn. Other striae S.	N.	S. 10° E.
†115	Hopewell	Road from Curryville to Hopewell Hill, top of a high hill.....	..	S. 15° W.
†117	"	Woodworth Settlement, N. of Hopewell Hill, near top of table-land.....	..	S. 25° W.
†118	"	Road from Hopewell Corner to German-town Lake, in a valley.....	..	S. 40° W.
†119	Coverdale	Dawson Settlement, $\frac{1}{2}$ mile S. of Turtle Creek, on flat table-land	..	S. 60° E.
†120	Dorchester	Budreau Quarry. Other striae S. 10° E.	..	S.

In the above table there are a large number of examples (No. 1 and Nos. 7 to 46) which shew the persistency of the south-easterly trend in the glacial grooves near the United States border, the most easterly courses being those in the parishes of St. George and Pennfield. Another group of lines (Nos. 47 to 55) which average only 15° east of south, is that which crosses the granite hills where they are widest. They are in the south part of Sunbury and east part of Charlotte counties. The striae east of this (Nos. 56 to 59, and 61, 53, and 82 to 92) descend through the cross valleys in the direction of the St. John River. A fourth group of striae is that which crosses the peninsula of Kingston, and the hill ranges eastward in Hampton and Upham (Nos. 64 to 80, 108, and 113 to 114), where the average is 10° east of south, with a few westerly courses in the deeper valleys. A fifth group of striae includes grooves around the city of St. John and eastward of it (as Nos. 93 and 95 to 103). These exhibit the greatest amount of westing (average south 20° west), being directed toward the harbor and roadstead of St. John. In the sixth group a return to an easterly trend (average south 36° east) is observable in the striae on the land east of St. John harbor, sloping toward the Bay of Fundy. (See Nos. 104 to 107, and 109 to 112.)

These several courses exhibit the influence of the hills and valleys of the southern counties in diverting the striating force from a direct southerly course. Some unusual departures from the normal course of the striae, in several of these groups, may have a bearing on the question of final or local glaciation in this region. Such are Nos. 22,

28, 37, 38, 45, 62, 67, 68 and 72; and the plasticity of the striating force may also be inferred from the peculiarities of Nos. 12, 13, 62 and 94.

The course of the grooves in the south-western part of Charlotte county, appears to be connected with the peculiar conformation of the sea bottom in the part of the Bay of Fundy which extends in front of the group of islands in the parishes of West Isles and Grand Manan. To the south-east of these islands there is exceedingly deep water, forming a gulf or abyss more than a hundred fathoms deep. It is widest toward the Nova Scotia shore, where the descent to the bottom of the gulf is very steep, there being 100 fathoms at Bryer Island, half-a-mile off the north-west ledge. A tongue of deep water extends from the abyss in the direction of Letite passage, and toward it, and the deeper water beyond, the glacial grooves in that part of the county converge.

II.—MODIFIED DRIFT.

A correct knowledge of the relation of the different members of the second group of surface deposit is of much importance, when for purposes of drainage, road building, etc., it becomes necessary to break up the covering of loose materials which rest upon the surface of the solid rocks in this region. A definite order prevails in the succession of the different members of this group (Modified Drift), which gives the clue to the natural drainage of the land, and to the proper position for sinking wells, locating drains, etc., but which is apt to be misunderstood, owing to the way in which gravelly hillocks and ridges of the oldest member of the group rise abruptly above the level flats or undulating surfaces formed by the beds of the second member.

This member usually consists of clay beds impervious to water, and hence from its upper edge overlaid by sandy beds, or from the lower edge, which often rests upon sand or gravel, springs are apt to rise and flow off. Much money is often fruitlessly expended in sinking water-wells, which might be saved by even a rudimentary knowledge of the relations of the various portions of the surface deposits to each other.

So also in the matter of choosing sites for brick-yards, much advantage would result to the manufacturer if more attention were given to the composition of the clay beds of this group, for they not unfrequently contain within themselves the proportion of clay and sand suitable for the manufacture of bricks. Or spots could be chosen where the sands of the upper member of the group are in contact with the clay beds, and supply the necessary quantity of sand. Attempts are some times made to operate brick-yards where neither of these condi-

tions are fulfilled, but where the sand for mixing with the clay has to be brought from a considerable distance.

In many places there are areas of arable land which remain wet, cold, and unproductive, owing to the fact that such areas are underlaid at a slight depth by clay beds forming shallow basins which hold the water and saturate the porous soil which covers them. In this case, as well as that referred to above, where springs come from the upper or under surface of the clay beds, a judicious system of drainage would greatly improve the land for agricultural purposes.

1.—*Stratified Sand and Gravel.*

(* Syrtensian Deposits.)

This member of the Modified Drift rests immediately upon the Boulder Clay, and there are sections at the coast where a gradual change from the mingled materials of the latter group to the grey stratified beds of the former is marked by the occurrence of a few irregular, alternating beds at the line of contact. Some of these layers being red boulder clay, and others grey gravel and sand. In the flat interior of New Brunswick this member consists largely of sand beds; but in the valleys among the southern hills much coarse material is mingled with the sand, and in narrow, confined valleys the deposit is apt to be composed largely of gravel, and to contain great numbers of boulders more or less rounded and the striae obliterated. The beds are distinctly stratified and often obliquely laminated. They are mostly of a grey or brownish color, owing to the fact that the clayey particles have been sorted out by the action of a swiftly moving current of water. In sections such as may often be seen in banks along the sea-coast, where the whole series of surface deposits is represented and well exposed, this member shews as a grey band separating the reddish boulder clay beneath from the red Leda clay in the upper part of the series.

Over the open plain of the interior of New Brunswick the sand beds are thin and mostly concealed by Leda clay, but among the hills southward of this plain, where the valleys are deep and narrow, and the cutting power of the current which sorted out the sand was brought into more active play, the arenaceous deposit shews itself from beneath the clay in the form of gravel ridges and domes, and becomes more conspicuous than in the flat country further north.

* Marine Shoals or Banks. For meaning and use of this name, see Can. Nat., vol. 8, No. 2 p. 106.

Classification of
gravel ridges.

The ridges or kames vary in form according to their relation to the neighbouring hills, and to the valleys and gorges between them. The principal forms are:

1st. The *Weather Shoal*. This is found on the north side of a hill, or on one or both sides of the northern entrance to the gorge or valley; it usually has a rounded form, slopes gently down to the low land in front, and often has a hollow behind it, partly separating it from the solid rock of the hill side.

2d. The *Lee Shoal*. This has gathered behind a hill or the outlet from a valley.

3d. The *Centre Shoal*. This is an accumulation of gravelly materials formed in the enlargement of a valley or in the open space beyond its outlet, or upon the tops of rocky ridges. *Giants Graves* and *Whalebacks* are local names for varieties of this type; the former are small, with steep sides, and consist usually of gravel throughout their whole depth; while the latter are large, gently rounded, and have usually a substratum of boulder clay.

4th. *Horseback*, *Boarsback* or *Escar*. This type of gravel bank usually extends along the top of rounded slate ridges, forming a crest sometimes many miles in length; or it forms a connecting bank between neighbouring hills, or the opposite slopes of the valleys. There is an endless variety of intermediate forms connecting these four types of gravel ridges, due to the varied action of the currents by which they were accumulated.

A description of the most characteristic of the gravel ridges or kames, is given in the following table, in which all the bearings are corrected to the true meridian. When two or more courses are given, the first is that of the northern end of the ridge. Ridges observed by Prof. L. W. Bailey are marked with an asterisk; those noted by Mr. R. W. Ellis with an obelisk.

No. 2.—TABLE OF KAMES AND GRAVEL RIDGES.

No.	PARISH.	LOCALITY.	Kind of Ridge.	Length in miles.	Direction.
1	Prince William	One mile S.W. of McAdam Junc. (E. & N. A. R. R.) at E. end of a granite ridge	Crescent-shaped lee-shoals and whale-backs.	.. {	S. 50° E.
2	St. James.	St. Croix River, W. side of, extending from Little Simsquich to Kean's...	Horseback (two courses)	1 3/4 {	S. 30° E.
3	"	E. side of Canons River, on high land at upper end of Lynfield road ..	Horseback.		S. 20° E.
4	"	On road to Oak Hill, separating Cranberry Lake from the source of Moannes Stream. A ridge in two parts, separated by a hollow running S.	Whaleback and Horseback.	1 3/4 {	S. 40° E.
5	"	On road to Basswood Ridge three miles S. of the last.	A sharp whale-back.	1 3/4 {	S. 50° E.
6	St. Patrick.	Valley of Digdegunash Riv. A series of ridges crossing the valley.	Giant's graves, whale back & weather shoal.	2 1/2 {	S. 25° E.
7	"	Clarence Ridge, mostly of boulder clay	Whaleback.	2 1/2 {	S. 40° E.
8	"	Morrison Ridge S. of Clarence	Whaleback.	1 1/2 {	S. 35° E.
9	"	A lower and flatter ridge, S. W. of Morrison Ridge and mostly boulder clay	Whaleback.	1 1/2 {	S. 40° E.
10	"	W. of Bobec L., flat-topped	Whalebacks and horsebacks.	1 {	S. 40° E.
11	Dumbarton ..	E. of Flume Ridge, in valley of Magaguadavic R.		3 {	S. 50° E.
12	St. George.	Valley of Magaguadavic R., between Pomeroy Bridge and Piskahegan River...	A succession of Kames.	1 {	S. 30° E.
13	Clarendon	S. W. corner, E. of McDougall Lake	Horseback.	1 1/2 {	S. 45° E.
14	Pennfield.	From S. end of Clear Lake, along west side of Popo Logan River.		2 {	about S. 40° E.
15	St. George.	Lake Utopia, S. of (parallel but less continuous ridges N. and S. of these)	Horseback.		S. 30° E.
16	Pennfield.	Below Cripp's Mill-stream, on road to Black's Harbor	Whaleback and weather shoal.	1 1/2 {	S. 40° W.
17	"	Pennfield Ridge, southern end of.	Giant's grave.	.. {	S. 50° W.
18	Musquash	Musquash River, W. of, on post road to Lepreau...	Gravelly plateau.	2 1/2 {	W.
19	"	S. of Musquash Marsh (E. of last)	Gravel ridge.	3/4 {	S. 65° W.
20	"	Musquash Harbor, west of "Narrows"	Whaleback.	1 1/2 {	S. 80° W.

No. 2.—TABLE OF KAMES AND GRAVEL RIDGES.—*Continued.*

No.	PARISH.	LOCALITY.	Kind of Ridges.	Length in miles.	Direction.
21	Lancaster	Pisarinco, ridge ending at Negro Head.	Flattened gravel ridge.	1 1/2	S. 60° W.
22	"	Manawagonish, longest course of Kames, on Post-road to Musquash	Flattened horseback.	1 1/2	S. 50° W.
23	Simonds	Mount Prospect, top of, ...	Whaleback.	1/2	S. 45° W.
24	"	E. side of Otter Lake. (For courses and distances of continuation of this horseback, see end of table)	Horseback.	1 1/2	W. S. 65° W.
25	"	Ben Lomond Hill, 400 paces W. of	Horseback and whaleback.	1 1/2	S. 20° E. S. 10° W.
26	"	Head of Loch Lomond, on road to Golden Grove, several parallel ridges at lower levels on hill side	Lee shoal.	1 1/2	S. 10° E.
27	Westfield	Carter's Point, on Long Reach, St. John River, height about 100 feet. ... A lower ridge on W. side of this	Whaleback.	1 1/2	S. 20° E. S. 10° W. W. or E.
28	"	N. of Harding's Point, W. end of Long R., 120 feet high (aneroid measure't)	Round flat-topped centre shoal.	1 1/2	
29	"	Ridge S. W. from Harding's Point, 115 feet high (aneroid measurement)	Triangular whaleback.	1 1/2	S. 65° E. E.
30	"	Brundage's Point, S. of, on slope of land up from W. shore of St. John R.	Whaleback, horseback, whaleback.	1	S. 30° W. S. 20° W. S. 20° E.
31	Kingston	Clifton, S. of Waddell's Lake (short)	Centre shoal.	1 1/2	S. 20° W.
32	"	W. of mouth of Bostwick's Brook (along road side) about 150 feet high	Whaleback.	1 1/2	S. 25° W.
33	"	Centreville, Lake at J. Williams's	Stony ridges.	1 1/2	S. 30° W. S. 5° W.
*34	Upham	Barnesville, opposite Dr. Brody's, and southward toward mill	Horsebacks.	1 1/2	S. 35° W. S. 60° E.
35	"	In valley of Germain Br'k.	Whaleback.	1 1/2	
36	Hammond (or Sussex)	Crossing valley of Hammond River, one mile below Fowler's Inn	Horseback.	1 1/2	
*37	"	John Wallace's. Ridge N. of Walton L. (Course of valley N. 10° E.)		1 1/2	S. 45° W.

North of Otter Lake, in St. John county, and separating it from a marshy tract dotted with ponds, is a remarkable horseback, over which runs the road to Loch Lomond. It begins on the W. side of the outlet

of the lake, about 100 paces from No. 24 of the above table. Prof. Bailey gives the following courses and distances:—

78 paces @ S. 81° W.	40 paces @ S. 64° W.	
20 " S. 68° W.	88 " S. 61° W.	} L. on both sides.
86 " S. 68° W.	108 " N. 72° W.	
65 " S. 73° W.	78 " N. 64° W.	} S. slope of ridge.
72 " N. 89° W.	75 " S. 45° W.	
		} Across end of ridge

In the region covered by the kames described in this table there are three tracts, each characterized by certain peculiarities in the ridges. In the middle tract, which includes the Oromocto and Nerepis valleys, the ridges are mostly short and irregular, and none are recorded in this table. In the other two tracts they are longer, more conspicuous, and frequently coincide with the course of the rocky ridges beneath, but while in the western tract they are directed to the south-east, in the eastern they generally trend to the south-west. It will be seen that the western group of south-east kames occurs in nearly the same district as the first group of glacial grooves, and the ridges coincide in direction with the course of the grooves; but in the eastern district, near the coast, there is a wide difference between the course of the gravel ridges and the striae grooves, the two running nearly at right angles with each other; or, as at Lake Utopia, diverging still more widely.

Three tracts of gravel ridges.

Lake Utopia discharges by a deep narrow channel into the Magaguadavic above its lower falls, but is divided only by a gravel ridge from tide level at L'Etang River. The dividing kame is a compound one, consisting in its eastern part of a whale-back or centre shoal, and in its western of a weather shoal terminating against a slate ridge, the two gravel ridges being partly separated by a shallow depression. The centre shoal begins back of Reardon's Corner, with a course south 45° west, and terminates in a point directed south 55° west; the connected weather shoal runs south 50° west against the ridge of clay slate. In a hollow south of the weather shoal, on the west side of L'Etang River are the striae Nos. 37 and 38 of the first table in this report. The courses of the kames and the grooves, therefore, diverge at this place as much as 120°.

Ridges at Lake Utopia.

The kames in the parish of Lancaster also diverge at wide angles from the course of the glacial grooves. The gravel banks and ridges begin to the westward of Carleton Heights and the hills about the falls and narrows of the St. John River. There are several ranges of kames in this parish, of which the most southerly begins with a lee-shoal west of Carleton Heights. Its surface, which has been worked over and levelled by the sea, extends south 25° west, and is slightly overlapped by a small weather shoal jutting out from a lower hill beyond,

Ridges in Lancaster.

Sandy flats back of Sand Cove separate this hill from another weather shoal which rises gradually to the rounded ridge terminating at Sheldon Point. The western end of this ridge shows a well-defined lee shoal cut across obliquely by the sea, and exhibiting one of the most instructive sections of the surface deposits to be seen near St. John.*

Toward Sheldon Point the boulder clay may be seen resting upon striated ledges of Huronian rock, and succeeding the clay westward are beds of boulders and gravel, shewing by their overlapping layers, a westward moving current. The swelling outline of the bank is seen to be due to the thickening of the layers over the axis of the kame; and the whole is covered by beds of leda clay with characteristic fossils. The striae of No. 94, of the first table in this report, which run transverse to the axis of the kame, are on the north side of the "lower hill" near Sand Cove mentioned above. The various parts of this kame are separated from that next northward by a valley filled with Leda clay and marine alluvium.

Middle Ridge
in Lancaster.

The middle ridge or kame is higher or more continuous than the last, and has been cut down to a nearly uniform level by the action of the sea. It has along its southern face a distinct raised beach extending about five miles to the westward of St. John. At points where the ridge has been cut in making excavations, its structure and the changes it has undergone may easily be perceived. Originally the kame consisted of a series of rounded ridges, in the hollows of which Leda clay was afterward deposited; although the clay abounds in boulders at some points and elsewhere is sandy, it is a pure clay in more sheltered places, and is recognizable by the red color of the mud it contains. Ridges and points of the pure olive-grey gravel of the kame project upward into, and sometimes through the red deposit, where the subsequent action of the waves has worn down both sets of beds to a uniform level and covered them with a sea-beach several feet in thickness, made up of the ruins of both deposits.

The larger size and the continuity of the range of gravel knolls, now worked down to a nearly uniform level, has served to protect a third series of ridges further north, from the action of the sea. A deep marshy or rather peaty hollow separates it from the middle kame. In the northern kame there are ridges shewing two courses, one south 25° west, the other south 50° west; the latter are nearly enveloped by the former and thus appear to be older. The striae No. 91 of the first table, with a course of south 40° east, are at the northern end of this group of gravel ridges, which begins on South Bay.

* This section is described at page 24 EE under "Leda Clay."

Digdeguash River. On the northern side of the range of hills through which this stream winds before entering the sea, there is a small valley about two miles wide and seven long, across which runs, in an oblique line, a series of gravel mounds and ridges which look as though they had been raised artificially. The mounds begin in a bank of gravel of the lee-shoal type, east down at the western entrance of the valley on its northern side near Falls Brook. To this bank succeed a number of mounds of the form locally known as "Giant's Graves," one of which is used as a grave yard for the parish church near by. These mounds extend along the bottom of the valley in the direction of a larger gravel ridge of a rhombic form lying in the middle of the valley. At a mound near the bridge over the Digdeguash, and at the rhombic mound, there are gravel pits, where the Leda clay beds, which fill the bottom of the valley, may be seen to rise upon and overlap the lower slopes of the gravel ridges. On the flat top of the rhombic mound are two depressions lined with clayey soil. The more easterly and smaller of these has a porous bottom, and the soil is only a heavy loam; but in the other and larger one, the Leda clay covering is sufficiently thick and fine to prevent the rain water from percolating through, and here there is a small pond of water.

Ridges in
Digdeguash
Valley.

Clay-lined
hollows on the
gravel ridges.

This large mound is in its turn connected by other sharp, oval mounds of the "grave" type, with a long gravel ridge extending from the bank of the Digdeguash River up against the shoulder of a granite hill on the south side of the valley. In this basin the course of the kames nearly coincides with the glacial grooves, as may be seen by comparing No. 28 of the first table with No. 6 of the second. The gravel knolls in this valley appear to rest on the Leda clay, but the sections exposed on their sides shew that they really have their bases beneath the clay.

Formation of Lake Basins.—The clay-filled hollows of the rhombic mound in Digdeguash valley exemplify on a small scale the process by which many lake basins in this region have been produced. The powerful current which throw up the gravel ridges, made corresponding hollows or basins wherever the configuration of the land permitted free and rapid erosion. In the basins thus prepared, the Leda clay was subsequently deposited and served the purpose of a lining impervious to water, when the land subsequently rose above the sea. In some cases the discharge from these lake basins is over rocky ledges, the (higher) barrier ridges of gravel remaining intact. Such is the case with Lake Utopia, referred to above. Spruce Lake, seven miles south-west of St. John, and the lake-like expanse at the mouth of the St. John River, are similarly confined by gravel ridges. In other cases the discharging stream has pierced the gravel ridge; a fine

Basin at
Harcourt Lake.

example of this is Harcourt Lake, a pond in Douglas Valley, in Queens County. The meeting of two currents at the outlet of this valley has caused the gravel which they swept along to accumulate near Welsford Station, where it has produced a triangular flat-topped bank. The bank is steep on the south-east, but slopes away gently on the north, and at the foot of this northern slope lies Harcourt Lake. The discharge from the lake is along the eastern side of the gravel ridge, which has been cut away by the force of the stream to within twenty feet of the bottom of the basin. At this level the stream lost its excavating power, and the Leda clay lining preserved the lake from further diminution of its volume. The Loch Lomond chain of lakes in St. John county, as also Bellisle Bay and Washdemoak Lake on the St. John River and Sherwood Lake and Clear Lake and others on the south side of the Nerepis Hills are basins, closed in the same way by gravel deposits.

A third class of lakes, or rather ponds, caused by the formation of gravel ridges or banks, are those without apparent outlet. These are generally small ponds which overflow and discharge through the surrounding gravel when raised by rain above a certain level; they are commonly seen at the sides of horsebacks, &c.

Tidal Erosion in the Bay of Fundy. In order that a comparison may be made of the effect of tidal wear in the Bay of Fundy, with the phenomena of the Gravel Ridge, or Syrtensian period, I give in the following pages the result of an examination of the soundings in various parts of that bay, as shewn by the Admiralty Chart. For although an ocean current, constantly setting in one direction, cannot be expected to produce exactly the same result in transporting loose materials on the sea-bottom as the tides which flow alternately up and down the bay, the agreement is sufficiently close to illustrate the method by which the gravel beds were built up.

Erosion in Passamaquoddy Bay.

In the Bay of Fundy the velocity of the tide varies from two to three knots at its mouth to seven or eight knots in the Parrsboro passage near its head. Near its mouth, on the New Brunswick side, a portion of the bay is separated by a chain of islands, and is called Passamaquoddy Bay. These islands present on a small scale a barrier similar to that which, during the period when the gravel beds were accumulated, separated the ocean waters on the north side of those on the south side of the southern hills of New Brunswick. Passamaquoddy Bay has two principal outlets among these islands, viz., Quoddy River (a salt water strait) and Letite passage. The rush of the tide through these passes causes a roaring sound which may be heard for many miles, and the whirlpools in them are strong enough to upset boats and careen large vessels; both channels are full of deep holes, ledges and

pointed rocks. At Quoddy River the tide passes over barriers having only fifteen fathoms of water at low tide, yet within, owing to the erosion of the tidal current, there is fifty fathoms in the narrowest and straightest part, and thirty fathoms where it merges into the shallower water of Passamaquoddy Bay; in the contour of the twenty and fifteen fathom lines, tidal erosion may be traced quite to the head of the bay on the Robbinstown shore, along which runs the channel that connects Quoddy River with the estuary of St. Croix River.

Opposite the Letite passage, tidal wear on the bottom of Passamaquoddy Bay is even more conspicuous. One would naturally expect to find in this bay the channel of such an important river as the Magaguadavic—the largest entering the sea between the St. John River and the United States border; yet no trace of it can be detected beyond the five fathom line; on the other hand, the tidal trough which begins inside the passage, with a depth of forty fathoms, may be traced up the centre of the bay through the thirty, twenty, fifteen and ten fathom contour lines. Even the small middle passage between McMaster's and Pendleton's Islands, has produced a hollow twenty-four fathoms deep.

Tidal wear at
Letite Passage.

Opposite each of the main inlets into Passamaquoddy Bay, beyond the deep water, but immediately in front of these openings, there is a shoal corresponding to the "centre shoal" described on a previous page as produced by the ocean current of a former period. And along the straight reach of the northern shore of Deer Island a channel has been made by the tide, such as the Arctic current which threw up the gravel beds of the post-pliocene period produced at many points in southern New Brunswick, where a similar obstacle opposed its course.

Centre shoals
in Passama-
quoddy Bay.

At St. John, like results have been produced by the flux and reflux of the tide in the narrow passage by which that river debouches into the Bay of Fundy. Although there is only six fathoms at low water on the reef which causes the falls (or rapids) at the mouth of the river, such is the force of the current that trenches of twenty-five fathoms deep below the falls, and thirty-three fathoms deep above it, have been formed.

In the open parts of the Bay of Fundy, especially in its upper half, there are ridges and hollows seemingly the result of tidal erosion. Thus in the center of the bay, between Quaco in New Brunswick and Margareville in Nova Scotia, there is a depression, outlined by the forty-fathom contour line, nine miles long and three wide; it lies just between the points of two ridges, outlined by the thirty-fathom contour line, which extend outward from either shore. Up in Chignecto Passage also, off Cape Enrage, there is a trough scooped out by the tide, which is outlined by the thirty, twenty-five and twenty-fathom contour lines.

Troughs in the
upper part of
the Bay of
Fundy.

And, further up the same arm, another, in the Cumberland Channel, between Peck's Point and Boss Point; this trough is bounded by the ten-fathom line, and through it the tide runs at the rate of four knots an hour.

But it is in the eastern arm of the Bay of Fundy—Minas Channel and Basin—that the scouring action of the tide is most conspicuous. The curve of this arm to the east has thrown the weight of the current on the eastern shore; and there, under Cape d'Or, is a trough outlined by the fifty, forty and thirty-fathom lines, scooped out to a depth equal to that of the deepest part of the bay between St. John and Digby, N.S.; yet in the intervening space between St. John and Cape d'Or the soundings shoal to twenty fathoms.

Erosion in
Minas Channel
and Basin.

Passing Cape d'Or and going further up, the bottom again rises to twenty-five fathoms, but soon sinks into another trough forty fathoms deep. This extends to Cape Split, where a sharp barrier reef, rising to within twenty-five fathoms of the surface, again intercepts the tide. Surmounting this reef the current again plunges down into a trench fifty fathoms deep, and rushes along through the Parrsboro' Passage at the great velocity of seven or eight knots, where the passage is deepest; but slackens to five or six knots, where, in the more open parts of the passage, the soundings rise to thirty fathoms. Here the contour lines of thirty, twenty-five and twenty fathoms take a bilobate outline, corresponding to the two arms of Minas Basin; at ten fathoms this line is trilobed, shewing the erosive influence of the tide even in the middle of the basin; for these three indentations answer to the Cornwallis, Avon and Shubenacadie rivers, as will be seen if the shallower contour lines be traced. A similar result of tidal erosion may be detected in Passamaquoddy Bay, where two tongues of deep water extend up from the basin in front of Letite Passage, on the contour line of ten fathoms, to Harwood and Hospital islands.

Gravel banks
formed in the
sea bottom.

Causes similar to those which produced the gravel and sand beds underlying the Leda clay in this region now operate to prevent the accumulation of mud in the deeper parts of the Bay of Fundy. Chief among them are the strong currents which have eroded the bottom in the way described above. The great tidal wave which enters the Bay of Fundy is compressed, between the Old Proprietor Ledge off Grand Manan Island and the North-West Ledge off Briar Island in Nova Scotia, into a space of twenty-four geographical miles—of which space twenty miles has an average depth of 100 fathoms, with a sea bottom of rocks and gravel. In this strait the tide runs at the rate of from two and a-half to three knots an hour, but immediately moderates its pace when this constriction is passed. In the more open part of the bay above this passage, the bottom becomes more sandy. On the

north side it is so only up to the forty-fathom line, but on the south side the bottom is sandy or gravelly up to the shore line, owing to the swifter current along this side of the bay. The violence of the current in the deep troughs of Minas Channel and Basin occasions the roughest bottom observable anywhere in the bay, for at these points rock and gravel compose the bottom over which the tidal waters run.

Gravel appears to have been gathered or exposed on the bottom by the wearing influence of these strong currents in certain parts of the bay; as, for instance, those banks which lie on each side of the deep water area eastward of Grand Manan. The bank on the New Brunswick side is of small extent, is separated from the Southern Wolf by a sinus or hollow outlined by the fifteen fathom line, and runs in an easterly direction. Scattered and irregular tracts of gravelly bottom extend along the Nova Scotian shore into comparatively shallow water, owing to the swiftness of the tide along the coast. But the most considerable gravel bank in the bay is that which begins on the eastern side of St. John Harbor and extends (mostly in soundings of twenty to thirty fathoms) nearly to Quaco Head. Along this coast the tide runs at the rate of two knots an hour, and the formation of mud-banks here has thus been prevented. A small gravel bank also extends along the western shore of Grand Manan Island, where the tide runs at the rate of three knots.

Conditions of the sea-bottom similar to those which prevailed over southern New Brunswick during the period marked by the accumulation of Leda clay, now exist in some parts of the Bay of Fundy, chiefly along the northern shore; and not a few of the species, the remains of which occur in the Leda clay, still maintain their existence in the bay. The north side of the Bay of Fundy having the slower run of tide, and being that along which the principal rivers enter, has in parts a muddy bottom. The only mud-bank of considerable volume, is that formed by the sediment which the St. John River carried to the sea. It begins at the harbor of St. John, and extends westward along the coast as far as the small islands called The Wolves, its outer limit coinciding nearly with the fifty fathom line. At the Wolves it connects by a narrow neck of clayey bottom with a deposit of mud in deeper water, consisting of the sediment of the St. John and the numerous small rivers west of it in St. John and Charlotte counties. This clayey deposit lies in the deepest part of the bay east of Grand Manan, having a width of twelve miles off Flagg's Cove; but it rapidly narrows to the southward and terminates at the last submerged ridge east of the Old Proprietor Ledge. To this point the Island of Grand Manan preserves it from the rush of the strong tidal current which enters the bay twice a-day south of that ledge.

Mud and clay
deposited in
the quiet
waters.

Mud flats in the upper part of the bay.

Narrower mud flats spread along the sides of the bay eastward of St. John in the shallower soundings. The longest is on the north shore, and lies between Quaco Head and Cape Enrage. Another exists on the opposite side of the bay between Cape Chignecto and Sand Cove opposite Cape Enrage. These mud banks, however, are exceptional, and of small extent when compared with the whole area of sea-bottom in the bay; for elsewhere, even in the deepest part, the bottom is mostly sandy, gravelly, or rocky, the coarsest bottom being where the tide runs with the greatest violence. As a rule, where the movement of the current exceeds one and a-half knots, mud is not deposited on the bottom of the bay.

2.—*Leda Clay* (Estuarine Deposits).

Composition of the Leda clay.

The gravels or Syrtensian beds graduate upward into Leda clay in all the low-lying part of southern New Brunswick. There is a great variety of composition in these clays, from the pure "brick clay" to a mass that is composed entirely of sand beds. Near the coast it consists usually of finely laminated clay beds, with thin partings of sand; but among the higher hills of the interior is chiefly made up of sand and clay in alternate layers. At a certain height, which has not been exactly measured, but which cannot be far from 200 feet above the sea-level, this deposit in the valleys of streams is composed chiefly, sometimes entirely, of sand. Where this occurs it is difficult to distinguish between the three members of the modified Drift—Syrtensian, Leda, and Saxicava—all being composed of similar materials. The point at which the Leda deposit in the valley of the Magaguadavic becomes a succession of sand beds, is in Brockaway Settlement, on the boundary between Charlotte and York counties. The corresponding point in the valley of the St. John River will be beyond the district to which this report relates, but a similar condition of the Leda clay was observed on some of its tributaries within the district. Thus at the Welsford station on the Nerepis River, there is an excellent example of the passage of Leda clay into beds of pure sand. It was visible in a section of the clay beds south of the station on the west side of the Nerepis River, made at a time when the European and North American railway was in process of construction.

Sand beds in place of clay at the Welsford Station.

At the points where the cuttings for this railway come opposite brooks descending from hills on the western side of the Nerepis valley, the whole thickness of the Leda clay consists of sand beds. But in tracing these beds in the cuttings along the track of the railway, north or south from the ravines in which the brooks run, the sand becomes more and more interlaminated with clay until it passes again into

ordinary Leda clay. The bearing of this fact upon the question of the depth of water in which the Leda clay was deposited will be readily seen.

Organic Remains of the Leda Clay.

Among the hills of the interior, organic remains are not often met with in the Leda clay, but on the lower levels near the coast a variety of fossils have been exposed by the wearing away of clay banks along the shores of the Bay of Fundy, and in cuttings on the railway lines. Among the fossils found are the following:—

Beluga sp?—A ramus of the lower jaw of a right whale has been found at the mouth of the Popologan River, having fallen from a bank of Leda clay, and is now deposited in the museum of the Mechanics' Institute in St. John. The bone is much worn, and has lost a great part of the gelatine once contained in its pores.

Phoca Gröenlandica Mull.—A skeleton of this species, which lacked the fore limbs and the vertebræ of the loins, was found several years ago at Hopkins' brickyard in Fairville, north of Carleton. The skull and hind limbs were nearly perfect, except that the left side was considerably worn. There were fifteen large vertebræ, with corresponding ribs; and there were also a number of caudal vertebræ. This skeleton was destroyed by the fire which devastated St. John in June, 1877. The following is a section of the beds from which it came (descending order):—

	FEET.	INCHES.	
<i>Saxicava</i> Sand.—Pale-brown sand, with intermingled gravel.....	2	0	Section at Fairville.
Pure pale-brown sand	8	0	
<i>Upper Leda Clay</i> .—Light brown sand and pale reddish clay, the sand-layers of irregular thickness.....	7	0	
<i>Lower Leda Clay</i> .—Dark grey sand and reddish clay in alternate layers of one-half inch to six inches in thickness, containing remains of mussels (<i>Mytilus edulis</i> *) and other small molluscs. The top of this clay was eroded before the deposition of the other clay.....	8	0	
Black sand, colored by organic matter, containing the same shells as the last, and the skeleton of the seal (<i>Phoca Gröenlandica</i>).....	0	6	
Red brick clay with partings about one foot apart of black sand and clay, colored by organic matter.....	4	6	
	30	0	

Another section, which exhibits clearly the relative positions of the

* A list of the remains of shell-fish and other invertebrates found in the Leda clay is given on a succeeding page.

sandy and clayey parts of the surface deposits, is that of Duck Cove, near Sand Cove, west of Carleton, viz:—

Section at Sand Cove, near Carleton.		FEET. INCHES.	
		FEET.	INCHES.
	<i>Saxicava</i> Sand.—Stratified sand, gravelly near the top and having a few scattered stones	3	0
	<i>Leda</i> Clay.—Red clay with the following shells: <i>Portlandia glacialis</i> , <i>Macoma calcarea</i> , <i>Nucula expansa</i> , <i>Buccinum undatum</i> , <i>Natica affinis</i> , &c.	16	0
	Red clay with seams of sand, viz :	FEET. INCHES.	
	Brown sand	0	6
	Clay with <i>Portlandia glacialis</i> , <i>Macoma calcarea</i> , <i>Mya truncata</i> , &c.	2	3
	Black sand with <i>Portlandia glacialis</i> , <i>Saxicava rugosa</i> , <i>Ophioglypha Sarsii</i> , &c.	0	3
	Red clay with <i>Portlandia glacialis</i> , &c.	0	9
	Black sand and clay with <i>Portlandia glacialis</i> , <i>Pandora trilineata</i> , <i>Lyonsia arenosa</i> , <i>Cryptodon</i> sp? a <i>Lacuna neritoides</i> (fide A. S. Packard)	0	3
	Red clay	0	6
	Black clayey-sand, fossils like those of the black sand above, with bryozoa, corals, <i>Ophioglypha Sarsii</i> , and a larger Ophiuran, species undetermined	0	6—
	Red clay with irregular layers of sand, bryozoa on small imbedded stones.	5	0
	<i>Syrtensian</i> or <i>Gravel and Sand Beds</i> .—Brown sand with lumps and irregular layers of clay	3	0
	Pure, buff and greyish-brown sand, distinctly stratified, with a few layers of red clay at the base	5	0
	<i>Boulder Clay</i> .—Coarse and sandy, with many glaciated stones ...	9	0
		46	0

The extremity of the gravel ridge or kame west of Sheldon Point, referred to in the section of the Syrtensian beds, presents a much thicker mass of deposits, but a similar succession.

Section at Manowagonish Beach.		FEET. INCHES.	
		FEET.	INCHES.
	<i>Saxicava</i> Sand.—Stratified sand and gravel	5	0
	<i>Leda</i> Clay.—Fine red clay with a few algae	0	0
	Beds of red and black clay, and of fine brown sand, with seams of black sand and clay. It contains algae—three or four species, including <i>Rhodomela</i> and a narrow <i>Fucus</i> ; also <i>Serripes Groenlandicus</i> , <i>Mytilus edulis</i> , and a Bryozoon.	0	0
	Red clay and gravel in alternate layers	0	0
	Red clay with some seams of grey gravel. In this clay are <i>Portlandia glacialis</i> , <i>Mya truncata</i> , <i>Balanus crenatus</i> , <i>Saxicava rugosa</i> , <i>Nucula expansa</i> , <i>Serripes Groenlandicus</i> , <i>Buccinum undatum</i> , <i>Natica affinis</i> , &c.; also algae	40	0

Syrtesian Beds.—Grey gravel with some clay; strongly marked

by beach structure, the southern end of the beds being cut off. It contains beds of boulders and large rounded

stones 0 0

Grey gravel beds, with few boulders; structure as the last.

except that the layers are nearly horizontal 50 0

95 0

These gravels are rounded up in the middle into a projecting ridge, which is covered by arching layers of Leda clay. The Saxicava sand is terraced on the south slope of the ridge, being a fragment of a raised beach, corresponding in height to the long beach formed on the slopes of the middle row of kames in Lancaster, referred to on a previous page. The above section exhibits the greatest thickness of modified drift so far observed in this part of New Brunswick.

A remarkable section of Leda clay was observed at Enniskillen station, on the European & North American railway. The station is on the northern slope of land from the foot of the Nerepis Hills, and is about three miles from their base. When this cutting was fresh it was marked in a singular manner by rows of miniature columns, visible along the face of the bank. On a close inspection the columns were found to consist of small vertical pipes in the sandy layers, supporting projecting layers of clay. The pipes had been formed in the sand by the cementing of its particles around fine rootlets of small plants and trees which had grown on the surface of the clay and sand, and pushed their roots through the layers of clay, one after another in succession, till they had penetrated and mellowed the whole bank. These miniature drain pipes exhibited well the penetrating power of roots, and their utility in improving the drainage of land where the circumstances are favourable. Here they penetrated to a depth of eight or ten feet, and mellowed a soil which otherwise would have been a water-soaked sand.

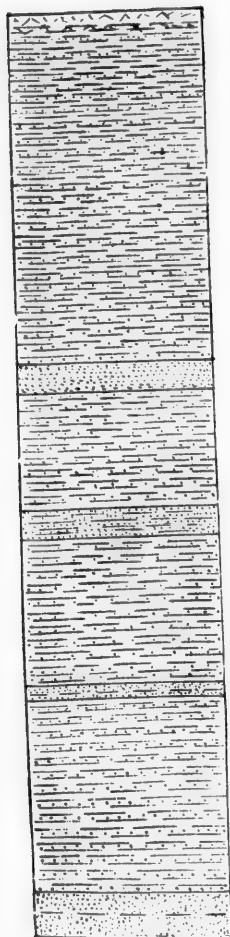
Section at
Enniskillen
station.

The Leda clay at this locality has been deposited in a shallow valley opening to the north, and gradually sloping to the Oromocto River. In the relative proportions of sand and clay it is intermediate between the deposits along the coast and those of Brockaway Settlement, &c., the sand and clay being in nearly equal proportions. The whole set of beds exposed consists of regularly alternating layers of clay and sand, except for short spaces at intervals in the section where there are sand beds only. These sand beds, however, have faint clayey partings, which are so spaced as to correspond to the clayey layers in other parts of the section. A sub-division into thinner laminae may be traced in the clay-layers, especially in the upper groups, where there is an average of about eight laminae to each layer.

Sand and clay
in equal
proportions.

SECTION OF LEDA CLAY, ENNISKILLEN.

Scale: One inch to a foot.



		Fr. lx.
a.	Loam, sand, and upper layers of clay disturbed by frost and vegetation.....	2 0
{ Sand bed on undulating layer		0 2
b.	Clay and sand in alternate layers, about 18 in number or $2\frac{1}{4}$ to an inch.....	0 8
{ Sand bed with thin clay laminae		0 2
c.	Clay and sand in alternate layers, about 20 in number, or 2 to an inch	0 10
{ Sand bed with thin seam of clay		0 1
d.	Clay and sand in alternate layers, about 25 in number, or 2 to an inch (layers finer and more homogeneous than those above)	1 1
{ Sand with imperfect seam of clay; very little		0 3

IX.

0

2

8

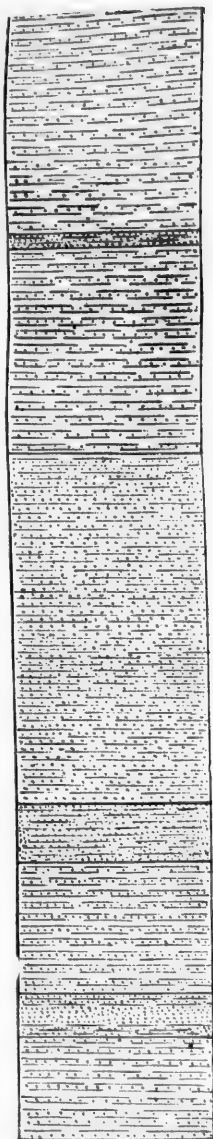
2

10

1

1 1

0 3



e.	{	Clay and sand in alternate layers, about 37	Fr. IX.
		in number, or $2\frac{1}{2}$ to the inch (two layers in the middle more sandy than the rest).	1 3
	{	Sand bed, with faint clayey partings	0 1
f.	{	Clay and sand in alternate layers, about	
		50 in number, or $3\frac{1}{2}$ to an inch	1 2
g.	{	Sloping bank, where the clay was dis-	
		turbed by frost and rain, clay and sand layers not clearly traceable	2 0
	{	Sand bed, with faint clayey partings	0 4
h.	{	Clay and sand in alternate layers, about	
		28 in number, or 3 to an inch	0 9
	{	Sand bed, with faint clayey partings near the top and bottom	0 3
i.	{	Clay and sand in alternate layers, about	
		16 in all, or $2\frac{1}{4}$ to an inch	0 7
			11 8

This section is notable, because its regularly alternating layers appear to point to a succession of seasonal changes during the time the Leda clay was being deposited. If the sand and clay layers be associated in pairs, there will be about 150; and if to these one-tenth be added for the bands which consist wholly of sand, the number will be raised to 160, or more, of pairs of layers, representing recurring cycles of time. The thickness of Leda clay exposed in this section is about twelve feet.

Details of
section.

	No. of Layers to an Inch.	Ft. In.
Loam sand and upper layers of clay, disturbed by frost and vegetation	..	2 0
Sand beds, an undulating layer.....	..	0 2
Clay and sand in alternate layers—18.....	2 $\frac{3}{4}$	0 8
Sand bed, with thin clay laminae	..	0 2
Clay and sand in alternate layers—about 20	2	0 10
Sand, with thin seam of clay.....	..	0 1
Clay and sand in alternate layers—about 25. (These are finer and more homogeneous than those above.).....	2	1 1
Sand bed, with an imperfect seam (a very little) of clay.....	.	0 3
Clay and sand in alternate layers—about 37. (Two layers in the middle are more sandy than the rest.).....	2 $\frac{1}{2}$	1 3
Sand bed, with faint clayey partings	..	0 1
Clay and sand in alternate layers—about 50.....	3 $\frac{1}{2}$	1 2
Clay and sand disturbed by frost, showing on a sloping bank, imperfectly	..	2 0
Sand bed, with faint clayey partings	..	0 4
Clay and sand in alternate layers—about 28	3	0 9
Sand bed, with faint clayey partings near the top and bottom ..	..	0 3
Clay and sand in alternate layers—about 10 large or 16 small...	2 $\frac{1}{4}$	0 7
		11 8

A section shewing heavy denudation of the Leda clay, and its relation to later deposits, is exposed near Lawlor's Lake, on the Intercolonial railway. At the shore of the lake, where it passes beneath a bed of fresh water marl, it contains *Portlandia glacialis*, *Saxicava rugosa* and *Astarte Banksii*. But 100 yards east of the old lake margin, it is overlaid by peat. Here it shews the following succession:—

	Ft.	In.
Pent	1	0
<i>Saxicava Sand</i> .—Grey sand.....	0	3
Clayey sand, with an abundance of <i>Mya arenaria</i> and <i>Macoma fusca</i> . (This is reckoned as part of the <i>Saxicava</i> sand here on account of its fossils; but as this section is 65 feet above the sea, it may be equivalent to the upper Leda clay of St. John.).....	0	6—0 9
<i>Leda Clay</i> .—Reddish sandy clay, with small stones, <i>Balani</i> , &c.....	1	2
Red sandy clay. Numerous shells of <i>Mytilus edulis</i> ; also <i>Cardium pinnulatum</i> , <i>Serripes Groenlandicus</i> , <i>Macoma Groenlandica</i> , <i>Saxicava rugosa</i> , var. <i>arctica</i> , <i>Buccinum undatum</i> , <i>Natica affinis</i> , <i>Balanus crenatus</i> , <i>B. Hameri</i> , <i>Toxopneustes Drobachiensis</i> , &c.....	0	2—1 4
Tough red clay without fossils	1	0
	—	—
	4	1

List of Marine Invertebrata of the Leda Clay.

In this list species collected by Mr. R. Chalmers in the Leda clay on the south side of Chaleur Bay, in the Gulf of St. Lawrence, are inserted for comparison with those of the southern counties of New Brunswick. The three columns indicate the occurrence of the remains at Passamaquoddy Bay (P. B.), other parts of the Bay of Fundy (B. F.), and Chaleur Bay (C. B.) respectively.

NAME OF SPECIES.	P. B.	B. F.	C. B.
Corals (with stony skeleton); two species undetermined.		*	
Ophioglypha; Sarsii, Lutken.		*	
Ophiuroid starfish, larger species; undetermined.		*	
Lepralia byalina, Johnston.		*	
Membranipora pilosa, Johnston.		*	
Cellepora pumicosa, Ellis.		*	
<i>Saxicava rugosa</i> , Linn.		*	
“ “ var. <i>pholadis</i> , Linn.		*	
“ “ var. <i>arctica</i>		*	
“ “ var. <i>rhomboides</i>		*	
“ “ var. <i>hiatella</i>		*	
<i>Mya arenaria</i> , Linn.; common.		*	
“ “ var. <i>acuta</i> , Say; common.		*	
“ “ var. <i>truncata</i> , Linn.; frequent.		*	
“ “ var. <i>Uddevallensis</i> ; common.		*	
<i>Lyonsia arcuosa</i> , Muller; frequent.		*	

List of Marine Invertebrata of the Leda Clays.—Continued.

NAME OF SPECIES.	P. B.	D. F.	C. B.
<i>Pandora trilineata</i> , Say; scarce.....			
<i>Macoma calcarea</i> , Chemnitz; common.....			
“ <i>fusca</i> , Say; common.....			
“ “ <i>var. Grœnlandica</i> ; common.....			
<i>Astarte Banksii</i> , Leach; scarce.....			
“ <i>compressa</i> , Linn.; infrequent.....			
“ <i>artica</i> , Møll., <i>var. lactea</i> ; infrequent.....			
<i>Cardium pinnulatum</i> , Conrad; common.....			
<i>Scorripes Grœnlandicus</i> , Chemnitz; common.....			
<i>Kellia suborbicularis</i> , Montague; rare.....			
<i>Cryptodon</i> , sp.? rare.....			
<i>Mytilus edulis</i> , Linn.; common.....			
“ “ <i>var. elegans</i> ; common.....			
<i>Modiolaria discors</i> , Linn.? rare.....			
<i>Nucula expansa</i> , Reeve, common (rare C.B.).			
“ <i>tenuis</i> , Montague; common.....			
<i>Leda pernula</i> , Møller, <i>var. buccata</i> ; frequent.....			
“ “ <i>var. tenuisulcata</i> ; common.....			
“ <i>minuta</i> , Fabricius; rare.....			
“ “ <i>var. caudata</i> ; rare.....			
<i>Portlandia glacialis</i> , Gray (<i>Leda truncata</i> Br.); very common. Name of Leda clay is taken from this species, ..			
<i>Yoldia sapotilla</i> , Gould; rare.....			
<i>Pecten tenuicostatus</i> (P. Magellanicus Lam.); scarce...			
“ “ a smooth variety; rare.....			
“ <i>Islandicus</i> , Chemnitz; common.....			
<i>Bela harpularia</i> , Couthuoy; infrequent.....			
“ <i>turricula</i> , Montague; not common.....			
<i>Natica affinis</i> , Gmelin (<i>Natica clausa</i>); common.....			
<i>Lunatia heros</i> , Say (dwarf and distorted); rare.....			
“ “ <i>var. Chalmersi</i> (<i>Canadian Naturalist</i> , vol. viii, p. 108); rare.....			
<i>Lacuna neritoidea</i> , Gould (ide A. S. Packard); rare....			
<i>Buccinum Grœnlandicum</i> , Chemnitz? rare.....			
“ <i>glaciale</i> , Linn.; scarce.....			
“ <i>tenuis</i> , Gray; not common.....			
“ <i>undatum</i> , Linn.; common.....			
<i>Tritonofusus Kroyeri</i> , Møll; rare.....			
<i>Neptunaea tornata</i> , Gould; not common.....			
<i>Balanus crenatus</i> , Brug.; common.....			
“ <i>Hameri</i> , Ascanius; frequent.....			

Depth of sea.
inferred from
fossils.

The period occupied in the deposition of the Leda clay was one of progressive shoaling along this coast. The lowest beds are of compact clay containing few organic remains, and these chiefly shells of *Portlandia glacialis*. At St. John this lower clay, which is of a dull red color, gradually passes upward into a fine dark colored clay varying in tint from dark grey and liver-brown to nearly black, owing to the organic matter disseminated through it; and here shells of *Portlandia glacialis* abound. It is this portion of the deposit which contains *Lyonsia*, *Cryptodon*, and other molluscs, also *Ophioglyphs*, none of

which indicate a depth of water less than that of the coralline zone. These dark beds are overlaid by another mass of red clay, which is generally of a browner hue than the lower red clay, and which contains such species as *Buccinum undatum*, *B. tenue*, *Mya truncata*, *Macoma calcarata* and *Saxicava rugosa*. A somewhat shallower sea is indicated by the occurrence at St. John of clay beds holding *Mytilus edulis* and *Cardium pinnulatum*, while a still further withdrawal of the ocean is shown by the presence in the sands which overlaid these clays of *Mya arenaria* and *Macoma fusca*.

3.—*Saxicava* Sand.*

(Terraces and Raised Beaches.)

The shoaling of the sea in which the Leda clay was deposited was brought about by successive upheavals of the sea bottom, which, as the land rose above the sea, produced terraces at several levels along the coast. The lowest of these terraces is about fifteen or twenty feet above the present level; they are common at the mouths of small streams entering the St. John and Kennebecasis rivers. The next terrace, which is more conspicuous, varies from forty to sixty feet, and can be seen to contain the three sub-divisions of the Modified Drift—gravel and sand at the bottom, clay in the central part, and sand (*Saxicava*) forming the top of the terrace. A third terrace begins at the height of one hundred feet and extends to one hundred and twenty feet. Another terrace was observed at a height of one hundred and fifty feet, and a fifth at three hundred and forty-five feet. These upper terraces are more gravelly than the lower ones, and not so regular in their outline. The terraces along the coast are in some cases remnants of sloping shore flats, or beaches which have been partly cut away by the sea. The height of the sloping banks which overlook the flats also vary. The following are some of the terraced slopes seen near St. John, which exhibit the irregularities of level:

Terraces
observed in
southern New
Brunswick.

	Manawago- nish Road and Beach.	Loch Lomond Road.	Mount Pros- pect Road.	Black River Settlement.
Raised beach.....	30	—	—	—
Terraced slope.....	—	—	—	36—60
Terraced slope.....	90—135	{ —95 —112	—85	—
Slope or summit of ridge....	150—155	140—	—	100—115
Terraced slope.....	—	—	345—350	—

* This term is used for the upper member of the Modified Drift, as the conditions under which it was formed appear to have been the same as those which produced the deposit of this name in the St. Lawrence Valley. But the only molluscan remains found in it in southern New Brunswick are those of *Mya arenaria* and *Macoma fusca*.

Influence on
growth of
certain trees.

In general the Saxicava sand does not attain a great thickness, but being the surface deposit in many parts of the country, it has an important influence on vegetation. Some of the most valuable timber trees grow plentifully on the sandy soils of this epoch. Extensive groves of white pine once covered the heavy beds of Saxicava sand which gathered in the valleys of streams at one or other of the terrace levels noted above. Most of the barrens or plains covered with ericaceous plants are due to the presence of these sands in wide-spread flats, and where the flats are water-soaked or badly drained, there are frequently fine groves of hackmatack or larch (*Larix*).

Thickness of
Saxicava sand.

The thickness of the Saxicava sand varies from two to nine feet where it has been exposed to the action of the surf when in process of formation; but at the mouths of streams banks of this sand are seen as much as twenty or thirty feet thick. Beds of bog iron ore are not infrequent in connection with this deposit, and it everywhere contains a small percentage of the oxide of iron and less frequently manganese, by which the upper layers of sand are sometimes cemented.

III.—MODERN ALLUVIUM, SHELL, MARL, PEAT, &c.

Extent of the
sunken area.

Subsidence of the Land.—The Saxicava sand was the last marine deposit formed in this region, and resulted from the wearing away of the older surface accumulations as the land rose above the ocean. This upward movement went on until the area of dry land extended considerably beyond its present limit. Since the Saxicava period peat bogs, marl beds and river alluviums have continued to grow upon the surface of the land and in the fresh water, except where their growth was arrested by subsequent subsidence. The depth of submergence cannot be shown to have been very great, but the area affected is of considerable extent. It includes the whole of the Bay of Fundy; part, if not the whole, of Nova Scotia and Prince Edward's Island; and the south-eastern half of New Brunswick from Passamaquoddy Bay to the Miramichi River. Proofs of this subsidence in Nova Scotia and at the head of the Bay of Fundy, are given in "Acadian Geology," Dr. J. W. Dawson. In the building of the Windsor and Annapolis railway evidences of subsidence in the Annapolis valley, similar to those observed by Dr. Dawson in the marshes at the head of the Bay of Fundy, were revealed; and I shall give here the outlines of facts observed in the southern counties of New Brunswick, having a similar bearing:

At Mill Cove, on Frye's Island, in Charlotte county, there is a deposit of peat, concealed at high tide mark by a gravel beach, but exposed in patches by the washing away of the sand at the lower levels

in the cove. It is said that the peat has been observed to extend to low-water mark.

On the western side of St. John harbor are the remnants of a considerable deposit of peat, which is now covered daily by the tide. It underlies the mill pond in Carleton, and once extended across to Navy Island in the upper part of the harbour. When St. John was first settled it is said that a gravel beach extended along the western side of the harbour from Old Fort Neck (the site of Fort La Tour) across this peaty flat in the direction of Sand Point. Mr. F. T. C. Burpee, whose granite works are situated in rear of the line of wharves and the streets which have been built along the course of this beach, informed me that he had driven piles in the bottom of the mill pond to secure a foundation for his buildings, and found there a soft deposit ten feet deep, at which depth the piles struck a firmer bottom. Two feet from the surface a bed harder than the rest of the soft deposit was penetrated.

Buried peat
beds at mill
pond in
Carleton.

The remnant of this deposit on Navy Island was examined by Rev. James Fowler, where, as at the mill pond, the peat occurs between high and low water marks, and contains the roots and stumps of several kinds of trees, standing where they grew. Among the stumps was a tangled mass of fallen trees of various kinds: birch, (*Betula lutea*), spruce (*Abies nigra*?) and fir (*Abies balsamea*). These trees are such as grow in an ordinary upland soil, and appear to have been at the border of the swamp in this direction, but further west the peaty deposit consisted largely of the roots of a horsetail (*Equisetum limosum*) and other marsh plants. On the north side of the mill pond a canal for sluicing logs into the pond was cut many years ago through the marshy flat which separated Old Fort Neck from Carleton, and here also the bed of peat was found. Patches of peat have also been observed on the opposite side of the harbor in Portland, at the cove between Straight Shore and Simond's Point.

In coves along the shores of the Kennebec River there are submerged flats which correspond to the buried peat beds of the coast. Excavations were made in one of these flats at Harris' Cove, in Rothesay, several years ago, for the purpose of testing the value of the peat as a fertilizer. Pits were sunk at various points near the shore to depths of from four to ten feet into this deposit; throughout its whole thickness it was found to consist of marsh-mud full of the roots and stems of various sedges and grasses such as now grow on the marshes along the rivers. The marsh peat is perfectly uniform throughout the depth examined; and though compact is easily cut out, and when exposed for a week or two to the atmosphere crumbles to a fine grey powder or mud. In this property, as well as in the absence of acidity

Sunken
marshes of the
Kennebecasis
River.

Value of marsh
peat as a
fertilizer.

and the abundance of fine mud mingled with peaty matter, this substance, as a fertilizer, is far superior to ordinary peat. It was used in the cultivation of root crops with the best result, the land dressed with it having given as good crops as that on which ordinary barn manure was used. It is not so lasting in its effect upon the land as the latter, for after the second year the grass which grew upon the soil where barn manure was used, was superior to that whereon the marsh-peat had been spread. If mixed with some substance which would improve its quality in this respect, the marsh-peat would no doubt prove a very valuable fertilizer. As there is such a thick mass of the peat in Harris' Cove, it is probable that all the other coves along the river, equally sheltered from the waves, and having tributary brooks, will be found to have similar beds of peat.

The roots of the marsh plants in this deposit are spread out in regular layers and support the base of the stems, shewing in the deepest pits where the old beach similar to that which forms the present shore was exposed. Besides the rooted stems of the marsh plants the peat abounds with the leaves of sedges, &c., in horizontal layers—smooth and shining leaves—with a golden gleam when first opened up, but turning black when exposed for a while to the air. Over these grassy layers were scattered leaves of hardwood trees: birch (*Betula lutea*), beech (*Fagus ferruginea*), maple (*Acer dasycarpum*), and alder (*Alnus incana*). The peat near the shore, where there is a steep, rocky hill, contained also twigs and small fragments of various trees, such as white and yellow birch (*Betula alba* and *B. lutea*), hemlock (*Abies Canadensis*), &c.

Continued
subsidence at
Passama-
quoddy Bay.

The subsidence of the land which gave opportunity for the slow and steady growth of this mass of peat, may not yet have altogether ceased on some parts of the coast, as, for instance, in Passamaquoddy Bay. Along the shores of this bay there are sites of the villages of a palæolithic people, similar in some of their arts and customs to the race found in this part of the continent when it was first visited by Europeans. These village-sites were probably abandoned before the white race entered the country, as no relics of European manufacture were found in the shell-heaps by which the village-sites are marked. The banks upon which the beds of shells have been heaped have been reached by the sea, and undermined by its waves, so that the shells are now scattered down the slope of the bank, and mingle with the stones of the beach below. I have not been able to learn, however, that the present inhabitants of these shores have noticed or heard of any encroachment of the sea in recent times.

Lacustrine Marl. Lacustrine marl has been reported from several places in the southern part of New Brunswick, but the only deposit

which has received special attention is that of Lawlor's Lake, five and one-half miles from St. John, on the Intercolonial railway. The lake is a small, deep pond enclosed among craggy limestone hills of the Laurentian formation; it originally stood about fifteen feet higher than its present level, and discharged by a small brook flowing from the western end. Subsequently the water was drained off at the eastern end, and the marl bed exposed. Finally the cutting to the railway level laid bare a larger area of the marl and again gave the lake an outlet from the western end.

This pond has been above the sea-level since the 38-60 feet terrace of the Saxicava period was formed. It is underlaid by a thin band of Saxicava sand along the margin, and a complete lining of Leda clay beneath the sand. The clay, which is of a reddish color, contains remains of the following marine species: *Tellina*, *Gröenlandica*, *Balanus crenatus*, *B. Hameri*, *Pecten Islandicus*, *Saxicava rugosa*, and *Astarte Banksii*. Between the clay and the overlying marl bed is an intermediate layer of a dingy grey color, more sandy than the clay and less calcareous than the marl, but containing a few shells of the fresh water species, in which the overlying marl abounds. The marl is spread over the whole of the basin in which the lake lies, up to the original water line; but the deposit is thickest and abounds most in shells at the two extremities, especially the eastern, where it attains a thickness of two feet. The species of fresh water molluscs which are most plentiful in the deposit, are: *Planorbis campanulatus* and *Lymnaea elodes*; *Cyclas similis* is also common, and *Lymnaea stagnalis* and *Anodon fluviatilis* less so. A smooth variety of *Valvata tricarinata*? is common in this deposit, and assumes some unusual forms, varying from the usual close coil to an open spiral.*

Peat. In a hollow adjoining the basin in which Lawlor's Lake is situated, and of nearly the same size, is a bed of peat which, like the shell marl of the lake basin, rests on Saxicava sand and Leda clay. The peat and marl appear to have been contemporaneous in origin, and are still forming in their respective basins. That in which the peat lies is shallow and drained by sink-holes in limestone rock at the eastern end.

Peat beds are quite numerous in the southern counties of New Brunswick, but usually not of great extent. Either a general or special reference to many of them will be found in the Survey Reports of this region, especially that for 1870-1.

Marine and River Alluvium. The marine or salt marsh alluvium is not so extensive in the south-west part of New Brunswick as at the

Antiquity of the deposit.

Thickness of marl bed.

Fossils.

* Prof. Alpheus Hyatt is now studying these peculiar forms of *Valvata*.

head of the Bay of Fundy. Musquash Marsh, the marsh east of the city of St. John, and Manawagonish Marsh, are the principal deposits. These are all dyked and converted into meadow land.

The fresh water alluvium is much more extensive. That of the St. John River covers many square miles of surface and is very fertile. The most continuous portion is on the east side of the river, between Fredericton and the outlet of Grand Lake; but there are large islands in the stream and flats attached to one side or the other of the river as far down as Oak Point, on the Long Reach, in King's county. Below Oak Point the river becomes deep and wide, and the alluvium or interval is on the tributary streams only, viz., the Nerepis and Kennebecasis.

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